NASA

National Aeronautics and Space Administration

Robotic Mining Competition

Kennedy Space Center Visitor Complex

May 16 - 20, 2016

Kennedy Space Center Visitor Complex

Design it.
Build it.
Dig it.

Safety Manual

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SAFETY AND THE NASA MINING ROBOTICS COMPETITION (NMRC)

Instilling a culture of safety is a value that every individual in the *NASA* community must embrace as we pursue *NASA*'s mission and vision. *NASA* Mining Robotics Competition (NMRC) has adopted safety as a core value and has established the framework for safety leadership in all aspects of the program.

NASA believes that the teams that take the lead in developing safety programs and policies have a positive and lasting impact on each team member, mentor, their communities, and their present and future work places. *NASA* recognizes the teams that demonstrate safety throughout their programs and are truly committed to developing and nurturing a safety culture.

Objectives

1. To provide an easy-to-use guide for important safety information providing NMRC participants with a basic set of requirements to maintain a safe environment during the build season and at competition events.

2. To provide a site specific Respiratory Protection Plan for KSC's Robotic Mining Competition as required by KSC-PLN-1910, "Respiratory Protection Plan for Robotics Mining Competition at Kennedy Space Center Visitor Complex".

3. To comply with the requirements of 29 CFR 1910.134, "Respiratory Protection" and KNPR 1820.4, "KSC Respiratory Protection Program".

SCOPE

This manual applies to anyone involved with the NASA Mining Robotics Competition including all student team members, faculty, volunteers, and support personnel while at the Kennedy Space Center Visitors Center.

RESPONSIBILITIES

Everyone is responsible for safety during team meetings and the design, build, travel, and event phases of the competition. Please read this entire manual for details on how to be safe.

Participants

As an NRMC participant, you are expected to:

- Be familiar with this manual as well as the safety-related requirements applicable to your work area.
- Work in a safe and responsible manner.
- Understand and follow established safety requirements.
- Use personal protective equipment (PPE), safe guards, and other safety equipment as required.

- Identify and report any unsafe or hazardous conditions to the arena chief, robopit chief, or volunteer coordinator. This includes work practices that may cause an accident. Encourage safe behaviors in everyone around you.
- Provide MSDS for any chemicals, paint, and batteries, etc. the team uses to the Robotics Mining Volunteer Coordinator. You can usually obtain these sheets from the manufacturer's web site or by calling the manufacturer directly.
- Become familiar with this safety plan

Volunteer(s) - NASA/KSC

- Lead by example. Practice the same safety behaviors that we expect from the teams.
- Provide guidance and encouragement on a safe working environment. .
- Provide leadership and guidance for proper tool, PPE and personal protective equipment usage and safety as outlined in sections below.
- Identify and report any unresolved unsafe or hazardous conditions to the Pit Administration supervisor. This includes work practices that may cause an accident. Encourage safe behaviors in everyone around you.
- Know where to find, and become familiar with the Material Safety Data Sheets (MSDS) for the BP-1 regolith material and related emergency procedures. (See Appendix A)
- Become familiar with this safety plan

INJURY REPORTING REQUIREMENT

Regardless of severity, report all accidents, injuries, and near misses to even the Robotics Mining Volunteer coordinator. Even injuries that you determine as minor may become serious if proper medical attention is not provided in a timely manner. Remember, each minor event can be a precursor to a major event.

Report to the Visitor's Center medical clinic (by bus loading area) for minor injuries or dial 321-867-7911 in case of an emergency.

If BP-1 material comes in contact with skin, flush for 15 minutes using the emergency eyewash/drench hose near the HEPA vacuum area or the hose located on the west side of the IMAX theater. If irritation occurs after flushing report to the Visitor's Center medical clinic (adjacent to bus loading area).

PERSONAL PROTECTIVE EQUIPMENT (PPE)

The use of personal protective equipment (PPE) is an important element to help ensure NRMC Participants are protected from hazards in the work area. The PPE Attendant will ensure that participates are provided the correct PPE for the task they are performing. The following describes the common PPE that you are required to wear as part of constructing a robot.

Specific PPE is required to place the robot in the bin (participants) and during robot operation/disturbance of regolith material (judges/regolith assistants). Participant PPE includes N 95 Filtering Facepiece, full body protective suits with hood and booties, dust goggles, and nitrile gloves when entering bin to place robot on BP-1 regolith. PPE for judges/regolith assistants inside the Caterpillar Mining Arena during robot operation includes full face Respirator with P100 filters or full face powered air purifying respirator (PAPR), full body protective suits with hood and booties, rubber boots, and nitrile gloves

<u>Body Protection</u>

Personnel entering the regolith bin or coming in contact with the BP-1 shall wear full body disposable coveralls, nitrile gloves and eye protection issued prior to entrance to the PPE Attendant. Caterpillar Mining arena. Personnel shall follow the following donning / doffing procedures;

Donning Protocol

1. Select appropriate size Tyvek coverall suit put it on over shoes
2. Select appropriate gloves and don overlapping Tyvek suit. Tape glove to Tyvek coveralls overlap to ensure skin is not exposed. Tape may also be applied above ankles and waist to contain excess Tyvek coveralls material.
3. Volunteers: Don rubber boots over Tyvek booties if working in regolith pit.
4. Participants: Place N-95 filtering face piece over nose and mouth. Adjust nose bridge to obtain a comfortable fit and prevent eye protection fogging. Place dust goggles over eyes and cover head with Tyvek suit hood.
    a. Put eye protection over eyes and cover head with Tyvek coveralls suit hood.
5. Volunteers: If entering Caterpillar Mining Arena during robot operation, don full face negative pressure respirator or full face powered air purifying respirator (PAPR) with P-100 filters and cover head with Tyvek suit hood.

Doffing protocol:

ALL: Remove hood then remove Tyvek coverall rolling down from inside of suit. Remove gloves taped to suit. Place coveralls in designated waste container.

<u>Participants:</u> Remove eye protection and return to PPE attendant.

Remove N-95 filtering face piece and discard.

<u>Volunteers:</u> Remove full face respirator and discard filters.

Wash hands and areas that have come in contact with BP-1.

Respiratory Protection

Personnel shall wear respiratory protection in accordance with Appendix B (KSC-PLN-1910) for NASA Mining Robotics Competition.

Eye and Face Protection

Participates shall wear safety goggles as required, inspect equipment for damage each time it is worn. If you wear prescription glasses, you must wear approved safety goggles over them to achieve adequate protection.

Eye and face protection is required when there is a risk of exposure to the following:

- Flying particles
- Airborne particulates

Hand Protection

Hand protection is designed to protect against heat, electrical, chemical and mechanical hazards. Use proper gloves and mechanical tool guards.

Gloves:
NRMC participants and volunteers will wear nitrile or equivalent when entering the mining tent. Volunteers may perform some tasks requiring the use of leather gloves which are worn on top of nitrile gloves.

Check your gloves for proper size, absence of cracks and holes, and good flexibility and grip before you wear them.

Foot Protection

Shoes must have closed-toes and heels to protect against foot injuries, regardless of work location. Flip-Flops, Sandals, Mules, Crocs, etc. *are not acceptable* when working on or near the robot or while attending *NASA* competitions.

In some cases, safety shoes or toe guards are appropriate for areas where heavy objects can fall on your foot.

Other Preventives

Ensure that team members or mentors are not wearing ties, loose clothing, jewelry, or hanging key chains when near or working on moving or rotating machinery. Tie hair back or cover it. The use of anything other than ANSI-approved, UL-Listed, or CSA rated eye protection is prohibited.

SAFETY REQUIREMENTS

Running and horseplay is not permitted at any time.

General Safety

- Follow safe work practices, safe use of all hand tools, and maintain a healthy attitude regarding safety.
- Always walk and work in a controlled and thoughtful manner.
- Wear closed-toe and closed heel shoes, gloves where needed, and use hearing protection if necessary.
- Keep full control of robot at all times with no one in the robot's path at any time.

Competition Safety

- Travel safely and carefully between the Pit and the Caterpillar Mining Arena.
- Demonstrate safe behaviors in the heat of competition.
- Exhibit a planned, safe lifting procedure of the robot,
- Make sure the robot is properly secured if you must work underneath it. Never work on the robot on an unstable surface.
- Welding, power tools and chemical use are prohibited.

Pit Station Safety

- Control access to your Pit area; visitors are required to comply with PPE rules. Keep your aisle clear for pedestrians and robot transit.
- When transporting your robot, politely keep pedestrians alert to your movement.
- *No* Team Station structures, signs, banners, or displays can be higher than 10 feet above the floor.
- Securely mount team pit station signs, banners, and displays to the structure.
- Maintain a clean, neat, and orderly Pit Station at all times. Remember, there are inspections after teams leave so be sure to include:
    - The floor in and around your Pit Station
    - Proper tool storage
    - Proper care of batteries and battery chargers
    - Tidy storage of personal belongings and equipment

SOLDERING

Soldering can be dangerous because of the heat from the iron and the chemical fumes and vapors released from the solder and flux, respectively. When soldering, observe the following points:

- Use lead-free solder only and solder with electrically heated soldering iron/gun only.
- No torches or open flames of any kind are allowed
- Wear eye and face protection.
- Solder in well-ventilated areas.
- Never touch the iron/gun. It heats to extreme temperatures that will cause severe burns.
- Prevent burns: Wear cotton clothing that covers your arms and legs.
- Always wash your hands with soap and water after handling solder.
- Work on a fire resistant surface.
- Keep your soldering iron in its protective holder when not actually being used.
- Do not leave any hot tools, where someone can accidentally contact the hot element.

HAND TOOLS

Constructing a robot will sometimes require the use of hand tools. Most people think of hand tools as wrenches, screwdrivers, chisels, and so forth, but the term also applies to any handheld tool or implement used to accomplish a task. This includes all sorts of things used to grasp, lift, push, pull, carry, or clean. Always use the proper tool for the job. Use of hand tools shall be in accordance with OSHA 29CFR 1910 Subpart P (1910.241 – 1910.244) – "Hand and Portable Powered Tools and Other Hand-Held Equipment ". Power tools will be operated by prototype shop personnel at the Bot Shop (in RoboPits tent)

Example: DO NOT use a wrench for a hammer or a screwdriver as a chisel.

Tool Rules

- Before using any tool, check to see if it is in good condition. Don't use defective, dull, or broken tools. Don't put them back on the shelf; remove them from service and notify the supervisors so they can be replaced or sent for repair.
- When using a screwdriver or other tools, place the work on a bench or hard surface. Do not hold the item in your hand.
- When using knives / blades, direct cutting strokes away from your hand and body. Be aware of those around you and wear leather gloves.

Tool Storage

- Store sharp-edged or pointed tools in a manner not to cause injury when personnel reach for tool.

- When carrying tools, cover the point or edges with shields. NEVER carry unshielded tools in your pocket.
- Don't leave tools on overhead work surfaces. They may fall and strike someone below. Store equipment in a location where it will not create a safety hazard or get damaged.

STORED ENERGY

Plan out the required activities when servicing or making repairs to the robot. Make sure all teammates are aware that work is being done on the robot. Address the following:
Ensure no one is working on the robot when it will be energized during repairs. Electrical Energy: Disconnect the electric power source

- Always de-energize the robot before working on it by unplugging batteries.
- Open the main circuit breaker ("re-set" lever is released).
- Miscellaneous Energy Sources:
- Relieve any compressed or stretched springs or tubing.
- Lower all raised robot arms or devices that could drop down to a lower position on the robot.

USED BATTERIES

Battery Disposal

- Delaware North will have battery collection bins located throughout the RoboPit Tent for robot nor the battery charger, use the battery protector safety plugs.
- Keep the battery charging area clean and orderly.
- Place your battery charger in an area where cooling air can freely circulate around the charger. Battery chargers can fail without proper disposal of spent or expired batteries.

ELECTRICAL SAFETY

Proper use and respect for electricity is paramount. The following are general guidelines for ensuring basic electrical safety requirements are met.

- All electrical devices shall be UL Listed.
- Inspect equipment cords and extension cords routinely to ensure they are in good condition.
- DO NOT Overload electrical fixtures and/or receptacles.
- Avoid the following electrical setups to prevent overloading:
- Power strip plugged into another power strip. ('Daisy Chaining')
- Extension cord plugged into another extension cord.
- Extension cord plugged into a power strip.
- ALL extension cords, with the exception of relocation power tap (RPT) SHALL BE UNPLUGGED WHEN NOT IN USE.

- Multi-device receptacle plugged into a power strip or extension cord.

AT THE EVENTS:

Setting up the Team Pit Station

- Bring and use work gloves for uncrating and re-crating.
- Design and set up your Pit Station safely - don't climb on items not meant for the task such as tables and chairs.
- Observe the ten-foot height limit for all portions of your pit station.

Working in the Pit

- Properly use power strips; don't daisy chain, for example.
- Keep the work area neat and orderly.
- Participants should be wearing approved personal protective equipment, PPE, in the Pit at all times, including:
- Safety goggles over prescription glasses, or prescription safety glasses that are agency approved
- Appropriate footwear - no open-toe or open heel shoes or sandals

Using the Practice Area/Field

Obey the rules for maintaining an "exclusion zone" around the area. This zone will help ensure that robots and moving parts will not exceed the practice area. It will help prevent accidents to those persons viewing the sessions or traveling nearby who may not be aware of the movement of the robots.
Of course, be sure to wear safety glasses and use safe lifting practices. Make sure the field is clear of debris, and be gracious by picking up any foreign materials. The designated volunteers are there to help maintain a safe area. Please cooperate with them.

SAFE ROBOT LIFTING, HANDLING, AND TRANSPORTING

Take a few moments to ensure your team knows how to lift your robot properly and safely. Practice the procedures prior to beginning the season so everyone has the same method and goals at the events.

Pre-Lift:

- Make sure the robot is safe to move:
    - Are all parts of the robot secured?

    - Is the robot powered off?
- Is anyone still working on the robot?
    - Have a pre-lift briefing to determine direction and path.
    - Ensure that the areas and paths are clear of debris and hazards.
    - Are there enough people to perform the lift safely? Two to four people are preferred.

The Lift:

- Appoint someone to coordinate the lift to make sure you are all ready to begin.
- Each lifter should place his/her feet close to the robot and adopt a balanced position.
- All persons should lift at the same time using proper body mechanics. These include:
- Lift with the legs, keeping your back straight
- Do not twist your body. Use your feet if you need to turn.
- Use proper hand holds to grasp the robot and make sure you have a safe, secure lift point before starting the lift.
- Bend your knees to a comfortable degree and get a good handhold. Maintain normal spinal curves.
- Tighten your stomach muscles and commence lifting the robot, using your leg muscles if you are lifting the robot up from the floor. Keep the robot close to your body, and coordinate lift speed with the others.
- There must be one person per 23 kg of mass of the mining robot, requiring four people to carry the maximum allowed mass.

Post-Match:

- Relieve all stored energy and open the main circuit breaker on the robot.
- Ensure that the robot is made safe prior to lifting it off the playing field, no dangling parts, etc.
- Remove debris from the playing field.
- Use the above “Pre-lift” and “During the lift” procedures.
- Use ramp and platform to enter and exit the bin. Climbing over the edge of bin is prohibited.

Transporting:

- Make sure the robot is secured to the cart to move back to the Robopit.
- Keep the cart under control at all times, especially when removing or placing the robot.
- Use patience and control when moving the robot, especially in crowded areas. Do not run.
- Ensure that the cart will not roll away or pose a hazard, especially upon robot removal. Use a chock block if necessary.

Appendix A - Safety Data Sheet for Black Point Lava, BP-1 Regolith

MATERIAL SAFETY DATA SHEET

for

AGGREGATE PRODUCTS

Section I - Product and Company Identification	
Material Identity (Trade Names): Aggregate Products (Limestone/Dolomite, Granite/Basalt, Sand, or Gravel)	
Manufacturer's Name: Rinker Materials Corporation	**Emergency Telephone Number:** 1-800-226-3768 ext. 2436
Address: 1501 Belvedere Road West Palm Beach Fl 33406	**Telephone Number for Information:** 1-800-226-3768 ext. 2436 **Internet Web Site:** www.cemexusa.com
	Preparer: Clayton Group Services, Inc.

Section II - Hazardous Ingredients/Identity Information					
Hazardous Components (Chemical Identity/Common Names)	CAS No.	OSHA PEL	ACGIH TLV	MSHA PEL	%
Component of all aggregate products: Crystalline Silica (Quartz) **(Note:** Aggregate products are naturally occurring materials of variable composition which may contain greater than 0.1% crystalline silica. For example, limestone	14808-60-7	30/(%SiO_2 +2) mg/m^3 (Total) 10/(%SiO_2 +2) mg/m^3 (Respirable)	0.05 mg/m^3 (Respirable quartz)	30/(%SiO_2+3) mg/m^3 (Total) 10/(%SiO_2 +2) mg/m^3 (Respirable)	0 -100%

typically contains less than 1% crystalline silica, granite and gravel up to 40%, and sand, up to 100%.) Component of limestone only: Limestone (calcium carbonate, $CaCO_3$) Particulates not otherwise classified	1317-65-3 -------- 	15 mg/m^3 (Total) 5 mg/m^3 (Respirable) 15 mg/m^3 (Total) 5 mg/m^3 (Respirable)	10 mg/m^3 10 mg/m^3 (Inhalable) 3 mg/m^3 (Respirable)	10 mg/m^3 (Total) 10 mg/m^3 (Total)	0-100% 0-100%

Section III - Physical/Chemical Characteristics

Boiling Point	Not Applicable	**Specific Gravity (H_20 = 1)**	2.45 - 2.80
Vapor Pressure (mm Hg)	Not Applicable	**Melting Point**	Not Applicable
Vapor Density (Air = 1)	Not Applicable	**Evaporation Rate (Butyl Acetate = 1)**	Not Applicable

Section IV - Fire and Explosion Hazard Data

Flash Point : Not Combustible	**Flammable Limits:** Not Flammable	**LEL:** N/A	**UEL:** N/A
Extinguishing Media: This material is noncombustible. Use extinguishing media appropriate to surrounding fire.			
Special Fire Fighting Procedures:. Be aware of runoff from fire control methods; particulate matter may clog sewers or waterways.			
Unusual Fire and Explosion Hazards: See Section V, Incompatibility.			

Section V - Reactivity Data

Stability: Stable	**Conditions to Avoid:** Avoid contact with incompatible materials.
Incompatibility (Materials to Avoid): Stable under expected conditions of use. Under unexpected conditions of use, material may react with hydrofluoric acid to produce a corrosive gas (silicon tetrafluoride). Also, contact with powerful oxidizing agents such as fluorine, boron trifluoride, chlorine trifluoride, manganese trifluoride, and oxygen difluoride may cause fire and/or explosions.	
Hazardous Decomposition or Byproducts: None known.	
Hazardous Polymerization: Not known to occur	**Conditions to Avoid:** See Incompatibility, in this section of MSDS.

Section VI - Health Hazard Data

Route(s) of Entry: **Inhalation?** Yes **Skin?** No **Ingestion?** Unlikely

Health Hazards (Effects described in this section are not believed to occur if exposures are maintained at or below OSHA PELs , MSHA PELs, and ACGIH TLVs. Because of the wide variation in individual susceptibility, these exposure limits may not be applicable to all persons and those with medical conditions listed below):

Acute Effects:

EYE CONTACT: Direct contact with dust may cause irritation by mechanical abrasion.

SKIN CONTACT: Direct contact may cause irritation by mechanical abrasion.

SKIN ABSORPTION: Not expected to be a significant route of exposure.

INGESTION: Expected to be practically non-toxic. Ingestion of large amounts may cause gastrointestinal irritation and blockage.

INHALATION: Dusts may irritate the nose, throat, and respiratory tract by mechanical abrasion. Coughing, sneezing, and shortness of breath may occur following exposures in excess of recommended exposure limits.

Use of aggregate products for construction purposes is not believed to cause additional acute toxic effects. However, repeated overexposures to very high levels of respirable crystalline silica (quartz, cristobalite, tridymite) for periods as short

as six months have caused acute silicosis. Acute silicosis is a rapidly progressive, incurable lung disease that is typically fatal. Symptoms include (but are not limited to): shortness of breath, cough, fever, weight loss, and chest pain.

Chronic Effects: Chronic bronchitis may result from chronic inhalation exposure. If unprotected skin is chronically exposed to dust, contact dermatitis may occur.

Aggregate products may contain more than 0.1% crystalline silica, which is a cancer hazard if inhaled. Cancer risk depends on duration and level of exposure. Prolonged exposure to crystalline silica can cause silicosis, a progressive pneumoconiosis (lung disease). Respirable dust containing newly broken silica particles has been shown to be more hazardous to animals in laboratory tests than respirable dust containing older silica particles of similar size. Respirable silica particles which had aged for sixty days or more showed less lung injury in animals than equal exposures of respirable dust containing newly broken particles of silica.

Solubility in Water: Not soluble

Section VI - Health Hazard Data (continued)

There are reports in the literature suggesting that excessive crystalline silica exposure may be associated with adverse health effects involving the kidney, scleroderma (thickening of the skin caused by swelling and thickening of fibrous tissue) and other autoimmune disorders. However, this evidence has been obtained primarily from case reports involving individuals working in high exposure situations or those who have already developed silicosis; and therefore, this evidence does not conclusively prove a causal relationship between silica or silicosis and these adverse health effects. Several studies of persons with silicosis also indicate an increased risk in developing lung cancer, a risk that increases with duration of exposure. Many of these studies of silicotics do not account for lung cancer confounders, especially smoking.

Carcinogenicity: Aggregate products (limestone/dolomite, granite/basalt, sand, and gravel) are not listed on the NTP, IARC, or OSHA list of carcinogens. However, in October 1996, IARC classified respirable crystalline silica from occupational sources as carcinogenic (Group 1). The NTP indicates that crystalline silica (respirable size) is a known human carcinogen (Group 1). These classifications are based on sufficient evidence of carcinogenicity in certain experimental animals and on selected epidemiological studies of workers exposed to crystalline silica.

Signs and Symptoms of Exposure: Chronic exposure to respirable dust containing crystalline silica in excess of applicable OSHA PELs , MSHA PELs, and ACGIH TLVs has caused silicosis, a progressive lung disease. Chronic tobacco smoking may further increase the risk of developing chronic lung problems. Not all individuals with silicosis will exhibit symptoms (signs)

of the disease. However, silicosis is progressive, and symptoms can appear at any time, even years after exposures have ceased. Symptoms of silicosis may include (but are not limited to): shortness of breath, difficulty breathing with or without exertion, coughing, diminished work capacity, diminished chest expansion, reduction of lung volume, right heart enlargement and/or failure. Persons with silicosis have an increased risk of pulmonary tuberculosis infection.

Medical Conditions Generally Aggravated by Exposure: Inhaling respirable dust and/or crystalline silica and/or limestone may aggravate existing respiratory system disease(s) or dysfunction. Exposure to dust may aggravate existing skin and/or eye conditions.

Emergency and First Aid Procedures:

Dust in Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water for a minimum of 15 minutes. Consult a physician immediately if irritation persists or later develops.

Dust on Skin: Wash affected areas thoroughly with soap and water. Consult a physician immediately if irritation persists.

Dust Inhalation: Remove exposed person to fresh air and support breathing as needed. Encourage victim to cough, spit out, and blow nose to remove dust. Consult a physician immediately if irritation persists or later develops.

Dust Ingestion: If person is conscious, give large quantity of water and induce vomiting; however, never attempt to make an unconscious person drink or vomit. Get immediate medical attention.

Section VII - Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled: Persons involved in cleaning should follow the protective controls defined in Section VIII of this MSDS. Spilled materials, where dust can be generated, may expose cleanup personnel to respirable dust containing crystalline silica. Cleanup personnel should use methods that minimize generation of airborne dusts, such as vacuuming, wet mopping, or moistening with water. Dry material from cleanup operations should be collected and placed in a suitable container for disposal or reuse.

Appearance and Odor: Granular white, gray, light tan and/or reddish odorless particles, ranging in size from powder to boulders.

Section VII - Precautions for Safe Handling and Use (continued)

Waste Disposal Method: Pickup and reuse clean materials. For disposal of non-reusable materials, follow applicable Federal, state, and local regulations. The materials are not listed as hazardous wastes under designations by the EPA or DOT.

Precautions to Be Taken in Handling and Storing: Silica-containing respirable dust particles may be generated by handling, crushing, cutting, grinding, or drilling aggregate products. Follow protective controls defined in Section VIII when handling these products.

Section VIII - Control Measures

Respiratory Protection : When exposed or likely to be exposed to dust above recommended limits, wear a suitable NIOSH-approved respirator with a protection factor appropriate for the level of exposure. Seek guidance from a qualified industrial hygienist, safety professional, or other suitably knowledgeable individual prior to respirator selection and use. For emergency or nonroutine operations (e.g., confined spaces), additional precautions or equipment may be required. Respirator use must comply with applicable MSHA or OSHA standards, which include provisions for a user training program, respirator repair and cleaning, respirator fit testing, and other requirements.

Ventilation	**Local Exhaust:** Provide general or local ventilation systems, as needed, to maintain airborne dust concentrations below the OSHA PELs, MSHA PELs, and ACGIH TLV. Local exhaust ventilation is preferred since it prevents release of contaminants into the work area by controlling it at the source.	**Other:** Respirable dust and quartz levels should be monitored regularly. Dust and quartz levels in excess of applicable OSHA PELs , MSHA PELs, and ACGIH TLVs should be reduced by all feasible engineering controls including (but not limited to) wet suppression, ventilation, process enclosure, and enclosed employee work stations.
	Mechanical (General): See above recommendations.	**Special:** None reported.

Skin Protection: Wash dust-exposed skin with soap and water thoroughly after handling. Wear work gloves and long sleeve work clothes to prevent skin contact. Wash work clothes after each use.	**Eye Protection:** Wear safety glasses with side shields as minimum protection from blowing dust. Dust goggles should be worn when excessively (visible) dusty conditions are present or anticipated.

Other Protective Clothing or Equipment: Wear suitable protective clothing, as needed, to prevent skin contact. Make available (if necessary) the use of eyewash stations, quick drench showers, and suitable washing facilities.
Work/Hygienic Practices: Avoid dust inhalation and direct dust contact with skin and eyes. Wear suitable protective clothing. If respiratory protection is used, institute a respiratory protection program that includes regular training, inspection, maintenance, and evaluation. Practice good personal hygiene and housekeeping procedures when using these products. Wash contaminated skin before eating, drinking, smoking, lavatory use, and before applying cosmetics.

DISCLAIMER:

The information contained in this Material Safety Data Sheet relates only to the specific material designated herein and does not relate to use in combination with any other material or in any process. The information set forth herein is based on technical data that the Company believes to be accurate. It is intended for use by persons having technical skill and at their own discretion and risk. Since conditions of use are outside the Company's control, the Company makes no warranties, expressed or implied, and assumes no liability in connection with any use of this information

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Respiratory Protection Plan
for
Robotics Mining Competition
at
Kennedy Space Center Visitor Complex

(APPENDIX B)

This Plan provides implementation for the requirements of the KSC Respiratory Protection Program for use of respiratory protection personal protective equipment (PPE). Specific responsibilities and requirements for compliance with the Respiratory Protection Program are not repeated in this Plan, but may be found in the most current versions of KNPR 1820.4, 'KSC Respiratory Protection Program' and 29 CFR 1910.134, 'Respiratory Protection'.

1. Hazard Assessment

a) The work area supervisor (or designated representative) is responsible to assess each work procedure to identify those tasks which may be hazardous due to the generation or release of dusts, fumes, mists, smokes, vapors, or gases into the workplace atmosphere. The supervisor will contact the MESC Environmental Health contractor (867-2400) to evaluate the task and identify the appropriate respirators for use based on the hazards identified.

b) Where the Hazard Assessment has been completed the respirator selection for the task will be added to Table 1.

c) The Hazard Assessment must be repeated when any change to the assessed operation or task is implemented that affects the generation or release of dusts, fumes, mists, smokes, vapors, or gases into the workplace atmosphere. These include:

(1) measures that increase the exposure hazard, such as increased operation duration or use of new processes, tools, or equipment that increase the rate of generation of the atmospheric hazard.

(2) measures implemented to reduce the exposure hazard, such as substitution of hazardous materials, use of ventilation systems to capture and exhaust air contaminants, or implementation of work practices designed to reduce employee exposure to the air contaminants.

d) When the revised Hazard Assessment has been completed, the work area supervisor will revise Table 1 to identify the new respirator requirement, when applicable.

2. Respirator Selection.

For each task assignment, the supervisor (or designated representative) will select the appropriate type of respirator from those listed in Table 1.

3. Training and Certification

a) Prior to assigning employees to any task requiring use of respirators, the supervisor will verify the currency of the employee's medical certification and training in the use of respirators.

(1) Medical certification. Each employee assigned to tasks requiring use of respirators is required to hold a current medical certification for the type of respirator assigned. The MESC Occupational Medicine contractor provides medical

certifications. Physical examinations for respirator use certification may be scheduled at the MESC Occupational Health Clinic. A medical use questionnaire must be submitted for each employee prior to scheduling for the physical exam.

(2) Training. Training for each type of respirator assigned is required for each employee and immediate supervisor. Training may be scheduled through the KISS Technical Training Office. Course numbers and descriptions are listed in Table 2.

(3) Please note that course number QG381JBO 'Respirator Fit Test' is required for every type of respirator assigned. Table 3 lists the types of respirators available for fit testing.

4. Sources of Respirators.

The supervisor is responsible for ensuring respirators are available for use when required.

a) **Manufacturer.** Air-purifying respirators may also be procured directly from the manufacturer or distributor. Procurements must be coordinated with the KSC Respiratory Protection Program Officer (867-6342) to arrange for fit-testing support through KISS Technical Training.

5. Respirator Inspection.

Each employee is required to inspect his/her respirator prior to each use and dispose of, repair, or return for maintenance those that do not pass inspection.

a) Disposable Respirators
- Check for holes in the filter element or damage such as loose charcoal canisters.
- Check straps for elasticity or deterioration.
- Check metal nose clip for rust or deterioration.
- Discard respirators that do not pass inspection.

b) Air Purifying Respirators
- Check the face piece for dirt, pliability, visible deterioration, cracks, tears, and holes.
- Check face piece lenses for proper mounting, cracks or scratches, broken or missing mounting clips.
- Check straps for breaks, tears, excessive wear, loss of elasticity, broken attachment snaps, and proper tightness.
- Check inhalation and exhalation valve assemblies for holes, warping, cracks, detergent or soap residue, and dirt.
- Check air-purifying element holder for cracks, worn threads, dirt, and missing or damaged gaskets.
- Check filters, canisters, and cartridges for dents, corrosion, and damage to threaded fasteners. Check the expiration dates. Check the protection afforded and limitations.

- Damaged components shall be discarded and replaced with repair parts provided by the respirator manufacturer in accordance with the manufacturer's instructions. Use of "equivalent" parts from other sources is not allowed. Only the manufacturer's parts are allowed. Respirators with damaged face pieces, visors, or cartridge holders will be discarded.

6. Respirator Maintenance.

a) Each employee is responsible for the maintenance of his/her own permanently issued air-purifying respirator.
   (1) Damaged components shall be discarded and replaced with repair parts provided by the respirator manufacturer in accordance with the manufacturer's maintenance instructions. Use of "equivalent" parts from other sources is not allowed. Only the manufacturer's parts are allowed.
   (2) Respirators with damaged face pieces, visors, or cartridge holders will be discarded and replaced with new respirators.

7. Cleaning and sanitizing of respirators.

These procedures are provided for use when cleaning and sanitizing respirators. They are general in nature, and the cleaning recommendations provided by the manufacturer of the respirators used by their employees may be used as an alternative, provided such procedures are as effective as those listed here. Equivalent effectiveness simply means that the procedures used must accomplish the objectives set forth below, i.e., shall ensure that the respirator is properly cleaned and sanitized in a manner that prevents damage to the respirator and does not cause harm to the user. Single use disposable respirators are exempted from this requirement.

a) Procedures for Cleaning Respirators
   (1) Remove filters, cartridges, or canisters. Disassemble face piece by removing speaking diaphragms, demand and pressure-demand valve assemblies, hoses, or any components recommended by the manufacturer. Discard or repair any defective parts.
   (2) Wash components in warm (43°C [110°F] maximum) water with a mild detergent or with a cleaner recommended by the manufacturer. A stiff bristle (not wire) brush may be used to facilitate the removal of dirt.
   (3) Rinse components thoroughly in clean, warm (43°C [110°F] maximum), preferably running water. Drain.

b) Procedures for Sanitizing Respirators

(1) When the cleaner used does not contain a disinfecting agent, respirator components should be immersed for two minutes in one of the following:

i) Hypochlorite solution (50 ppm of chlorine) made by adding approximately one milliliter of laundry bleach to one liter of water at 43°C (110°F); or,

ii) Aqueous solution of iodine (50 ppm iodine) made by adding approximately 0.8 milliliters of tincture of iodine (approximately 1 teaspoon) to one liter of water at 43°C (110°F); or,

iii) Other commercially available cleansers of equivalent disinfectant quality when used as directed, if their use is recommended or approved by the respirator manufacturer.

iv) Rinse components thoroughly in clean, warm (43°C [110°F] maximum), preferably running water. Drain. The importance of thorough rinsing cannot be overemphasized. Detergents or disinfectants that dry on face piece may result in dermatitis. In addition, some disinfectants may cause deterioration of rubber or corrosion of metal parts if not completely removed.

v) Components should be hand-dried with a clean lint-free cloth or air-dried.

vi) Reassemble face piece, replacing filters, cartridges, and canisters where necessary.

vii) Test the respirator to ensure that all components work properly.

8. Respirator Storage.

Permanently issued respirators must be stored in a clean, dry location (preferably in a box or plastic bag), away from direct sunlight or excessive heat.

9. General Use Instructions.

a) **Pre-Use Inspection.** Each respirator user will conduct a pre-use inspection prior to each use in accordance with the procedure in section 5.

b) **Cartridge/Filter Replacement.** Cartridges with service life indicators will be replaced in accordance with manufacturer's instructions. Otherwise cartridges/filters will be replaced after every 8 hours of continuous use (1 shift) unless recommended otherwise by MESC Environmental Health. Particulate filter cartridges may be worn until filter loading affects inhalation resistance.

c) **Facial hair.** Respirators with tight-fitting face pieces may not be used by employees with facial hair that comes between the face piece sealing edge and the face or may otherwise interfere with the function of the inhalation/exhalation valves.

d) **Leak Check.** An operational leak check is required prior to use of any respirator.

(1) All air-purifying respirators. All air-purifying respirators will be leak checked prior to use in accordance with the manufacturer's instructions or the following procedure.

i) Positive pressure test. Don the respirator. Close off the exhalation valve and exhale gently into the face piece. The face fit is considered satisfactory if a slight positive pressure can be built up inside the face piece without evidence of

ii) outward leakage. For most respirators this method of leak testing requires removal of the exhalation valve cover. The valve cover must be replaced after the test.

iii) Negative pressure test. Don the respirator. Close off the inlet opening of the cartridge(s) by covering with the palm of the hand(s) or by replacing the filter seal(s). Inhale gently so that the face piece collapses slightly, and hold the breath for 5-10 seconds. The fit test is considered satisfactory if the face piece remains in its slightly collapsed condition and no inward leakage is detected.

(2) Manufacturers Recommended User Seal Check Procedures.
The respirator manufacturer's recommended procedures for performing a user seal check may be used instead of the positive and/or negative pressure check procedures.

e) **Leaking Mask Procedure.** If the user detects odor or other indications of leakage while using a respirator, the user must immediately exit the work area and repeat the operational leak check. When a leak check cannot be satisfactorily performed, inspect the respirator (Section 5.a)). If inspection is satisfactory, replace the filter element or cartridge. If leakage still persists, stop work and notify the supervisor.

Table 1. Tasks Assessed by Environmental Health

Robotics Mining Preparation and Competition					
Exposure Group/Task Description	**Task Description**	**Hazard**	**Exposure Frequency/Duration**	**Recommended Personal Protective Equipment**	**Filter/Cartridge Schedule**
Contestants (College Students)	Placing robot in regolith bin prior to mining and removing after mining attempt	Respirable particulates, crystalline silica (BP-1)	Short Term, As required estimated to be <45 minutes per day	Filtering Facepiece with N95, Tyvek suits with hood and booties (or equivalent), dust goggles, nitrile gloves (or equivalent)	N/A
Judges/Regolith resetting (NASA)	Inside tent during robot operations. May include resetting/raking/shoveling Regolith and changing air conditioner unit filters	Respirable particulates crystalline silica (BP-1)	Inside tent during multiple robot mining attempts (15 minutes each. Additional exposure through continued work with regolith bin (resetting).	Full Face Respirator with P100 filters or Full Face Powered Air Purifying Respirator (PAPR), Tyvek suits with hood and booties, rubber boots, nitrile gloves (or equivalent)	P100 filters/once per shift or every 8 hours (whichever occurs first)

Table 2. Respirator training courses available through KISS Technical Training

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QG360OSH	Selection, Use, Care, And Maintenance Of Negative Pressure Respiratory Protection Equipment
QG361OSH	Selection, Use, Care, And Maintenance Of Negative Pressure Respiratory Protection Equipment Re-Certification (Annual)
QG381OSH	Respirator Fit Test

Table 3. Air-purifying respirators

Manufacturer	**Type**	**Model Number**	**Size**	**Part Number**
3M	Full face	6000 Series	Small	6700
3M	Full face	6000 Series	Medium	6800
3M	Full face	6000 Series	Large	6900
3M	Full face	Ultimate FX	Medium	FF-402
3M	Belt Mounted PAPR	3M GVP Series	M-series hood	GVP-PSK2
3M	Belt Mounted PAPR	3M GVP series	With 6000 series facepiece or 7800 facepiece	GVP-1 NiMH
M	Face Mounted PAPR	3M Powerflo	With 6000 series facepiece or 7800 facepiece	6800PF
3M	PAPR	3M Versaflo	S655 Hood	TR-300-ECK

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